Effects of Eutrophication and Habitat Alteration on an Endangered Species and Implications for Dissolved Oxygen Criteria

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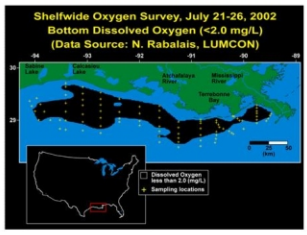
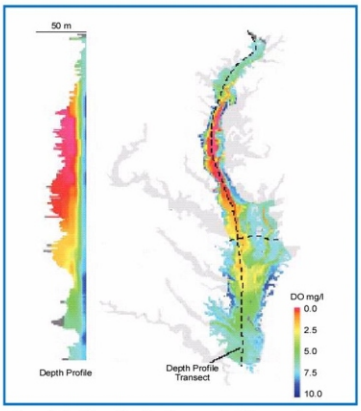
Abstract

Estuarine eutrophication, hypoxia, and endangered species are concerns for EPA, other federal and state resource agencies, and the public. Eutrophication associated with nutrient run-off from terrestrial-based sources can be a primary factor causing low dissolved oxygen (DO) concentrations. Water containing DO ≤2 mg/L is considered hypoxic, whereas water containing no dissolved oxygen is anoxic. Habitat alterations can have negative impacts on DO which can adversely impact the fauna, especially more sensitive species. Flow-through acute tests were conducted with hatchery-produced endangered shortnose sturgeon, *Acipenser brevirostrum*. Sturgeon were exposed to ranges of DO, salinity and temperature representative of southeastern coastal rivers and estuaries during spring and summer. The exposure apparatus was unique and first described in our publication (Campbell and Goodman 2004). We collaborated with the U.S. Fish and Wildlife Service to obtain sturgeon, and with the National Marine Fisheries Service (NMFS) Office of Endangered Species to perform the research. We found an increased sensitivity to low DO in these fish with increased temperatures. This is important as higher temperatures coincide with minimum DO during summer. Because young-of-the year shortnose sturgeon were especially sensitive to low DO, our results were important in deriving Ambient DO Criteria for Chesapeake Bay and its Tidal Tributaries (developed by EPA Region III, EPA Chesapeake Bay Program Office, in coordination with the Office of Water). The results also were cited extensively in EPA's biological evaluation of the Chesapeake Bay DO criteria, and by NMFS in their Endangered Species Act biological opinion on the criteria. The data should prove valuable to states along the Atlantic seaboard in establishing total maximum daily loads and maintaining suitable habitat for extant shortnose sturgeon populations. At the conclusion of the experiments, these often unobtainable fish were preserved and distributed among eight museums across the nation for inclusion in their ichthyological collections.

(Photo from The VA. Fish and Wildlife Information Service)





The extent of low dissolved oxygen in Chesapeake Bay during summer 1998. Figure from US EPA Chesapeake Bay Program (www.chesapeakebay.net).

Introduction and Approach

Computer-controlled vacuum degassing system used to deliver seawater at selected flow rates, and to control DO concentrations and temperature.

Estuarine eutrophication, hypoxia, habitat alteration, and endangered species are concerns for EPA, other federal and state resource agencies, and the public. Urbanization, agriculture, industry, and habitat alteration can all directly and indirectly contribute to lowered dissolved oxygen concentrations (DO). Our lakes, rivers, estuaries and near coastal waters are all subject to anthropogenic activites located both on their shores and sometimes to activities hundreds of miles away. Habitat alterations such as low land fill, dredging and water diversion, can also have negative impacts on DO which can adversely impact the fauna, especially more sensitive species.

The anadromous shortnose sturgeon *Acipenser brevirostrum* occurs on the east coast of North America from the St. John River, New Brunswick, Canada, south to the St. Johns River, Florida. Historically, they were abundant enough that they were commercially harvested. By 1967, however, the populations had declined to the point that the species was listed as endangered. Juvenile shortnose sturgeon appear to occur primarily in low salinity estuarine and tidal freshwater habitats. There is considerable concern that their habitat may be adversely impacted by eutrophication, industrial pollution, and dredging.

To determine their sensitivity to low DO, we conducted flow-through acute tests with hatchery-produced fish. Fish ≤ 134 days old were exposed to ranges of DO, salinity, and temperature expected in the southeastern United States coastal river/estuary interfaces during spring and summer.

Results and Discussion

LC50 values obtained in the four tests ranged from 2.2 to 3.1 mg O_2/L (Table 1). Survival of fish in control treatments that contained near-saturation concentrations of DO was 100%. Most mortality in experiments occurred rapidly, typically within the first four hours. Young of the year juvenile sturgeon (134-day-old) were quite sensitive to low DO in acute tests at low salinities, particularly when tested at high and perhaps stressful temperatures as may occur during summer. Because of the sensitivity of sturgeon to low DO, their DO requirements had an important impact on establishment of DO criteria for Chesapeake Bay, as described in the document Ambient DO Criteria for Chesapeake Bay and Its Tidal Tributaries.

Similar experiments were also performed on numerous other ecologically and commercially important young of the year species commonly found in southeastern estuarine and coastal waters.

These results, through their effect on setting water quality criteria for DO will have an impact of target nutrient loading rates and the TMDL process for states along the Atlantic seaboard.

Detailed results of this study are published in:

Campbell, J. G. and L. R. Goodman. 2004. Acute sensitivity of juvenile shortnose sturgeon to low dissolved oxygen concentrations. Transactions of the American Fisheries Society 133: 772-776.

Test conditions and LC50 values (mg DO/L) for young-of-the-year shortnose sturgeon exposed to low DO concentrations.

Acclimation[a] (days)	Age (days)	Temperature (°C)	DO Conc. range[b] (mg/L)	Salinity (o/oo)	Duration (hrs.)	LC50 (mg/L)	95% C.I.[c] (mg/L)
13	≈104	21.8 - 22.4	1.9 - 8.4	4	24	2.2	2.2 - 2.3
15	≈134	26.0 - 26.4	1.7 - 7.8	4.5	24	2.2	2 - 2.4
"	"	"	1.7 - 7.7	"	48	2.2	1.9 - 2.4
"	"	"	1.6 - 7.7	"	72	2.2	1.9 - 2.4
12	≈77	24.6 - 25.0	2.2 - 8.0	2	24	2.6	2.3 - 3.1
12	≈100	≈28.4 - 29.2	2.2 - 7.4	2	24	3.1	-[d]

[a]Number of days within ± 1 °C of nominal test temperature prior to testing.
[b]Range in mean measured exposure concentrations.
[c]C.I. = confidence interval.
[d]Not determined.